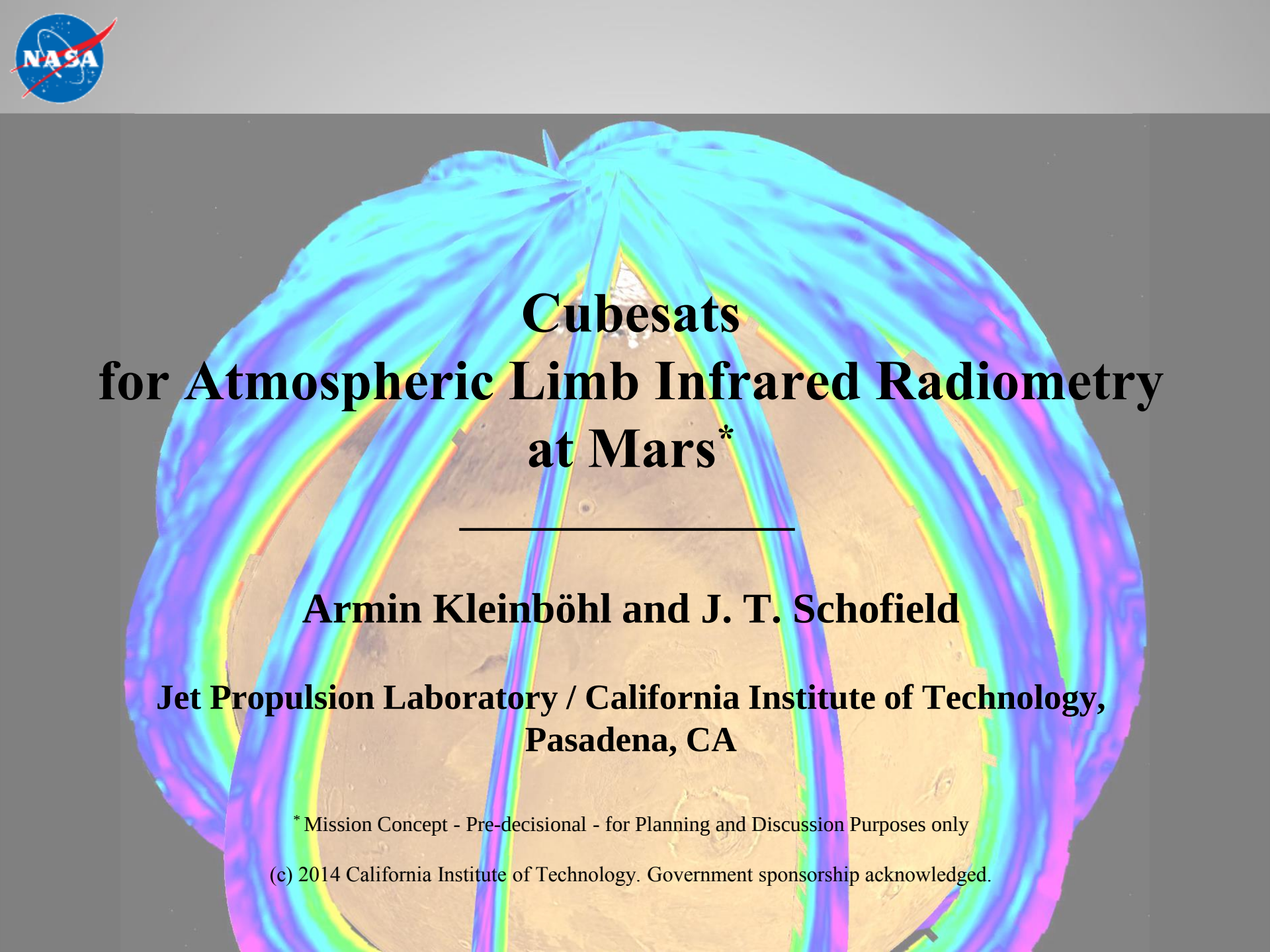

Cubesats for Atmospheric Limb Infrared Radiometry at Mars*

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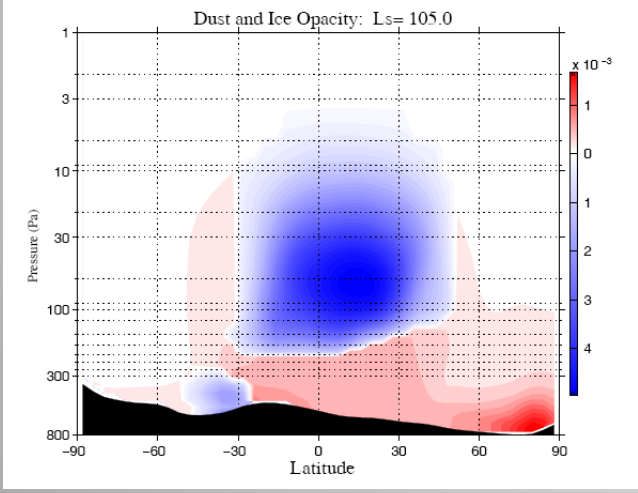
* Mission Concept - Pre-decisional - for Planning and Discussion Purposes only

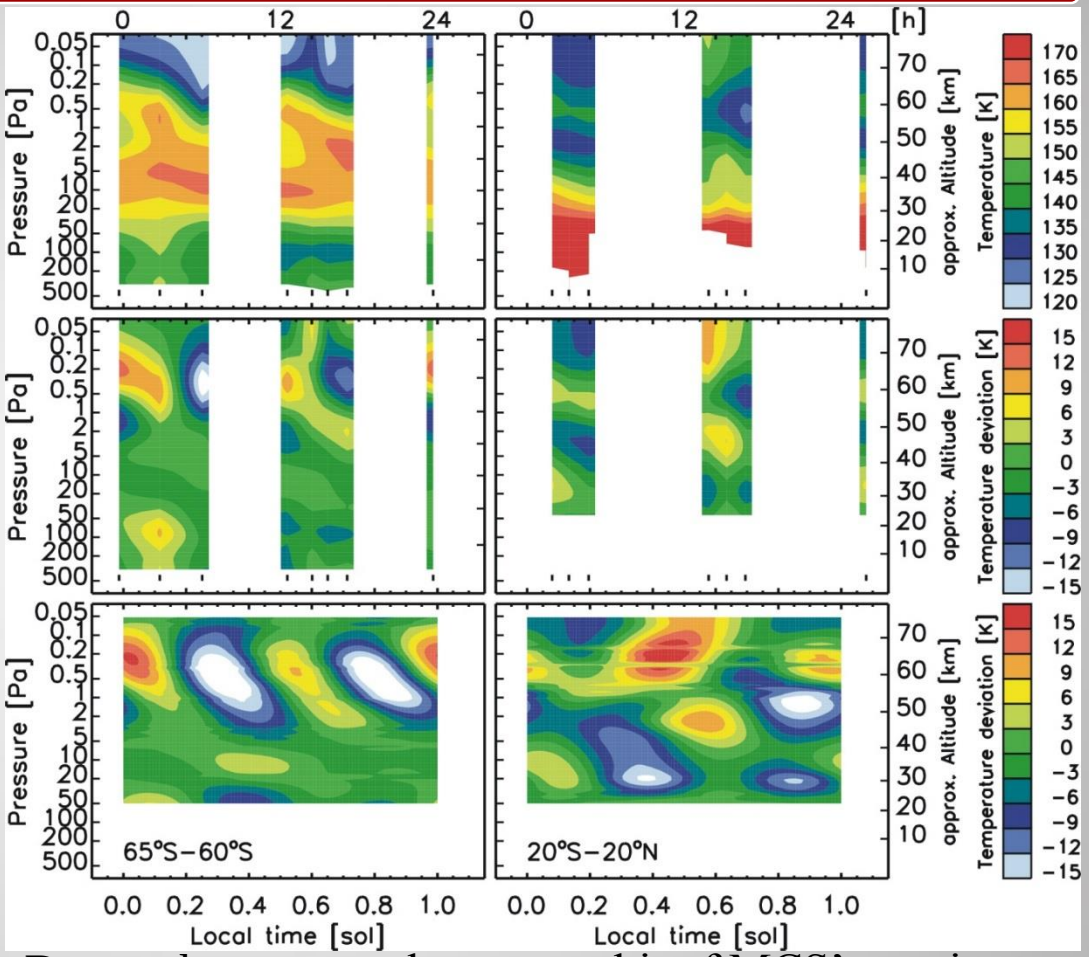
What is the magnitude of semi-diurnal temperature anomalies?

Mars Climate Sounder (MCS) measurements reveal temperature anomalies with semi-diurnal period (tides) in Mars' middle atmosphere.

Semi-diurnal tides are caused by the radiative effect of water ice clouds. In turn, tides modulate the occurrence of clouds.

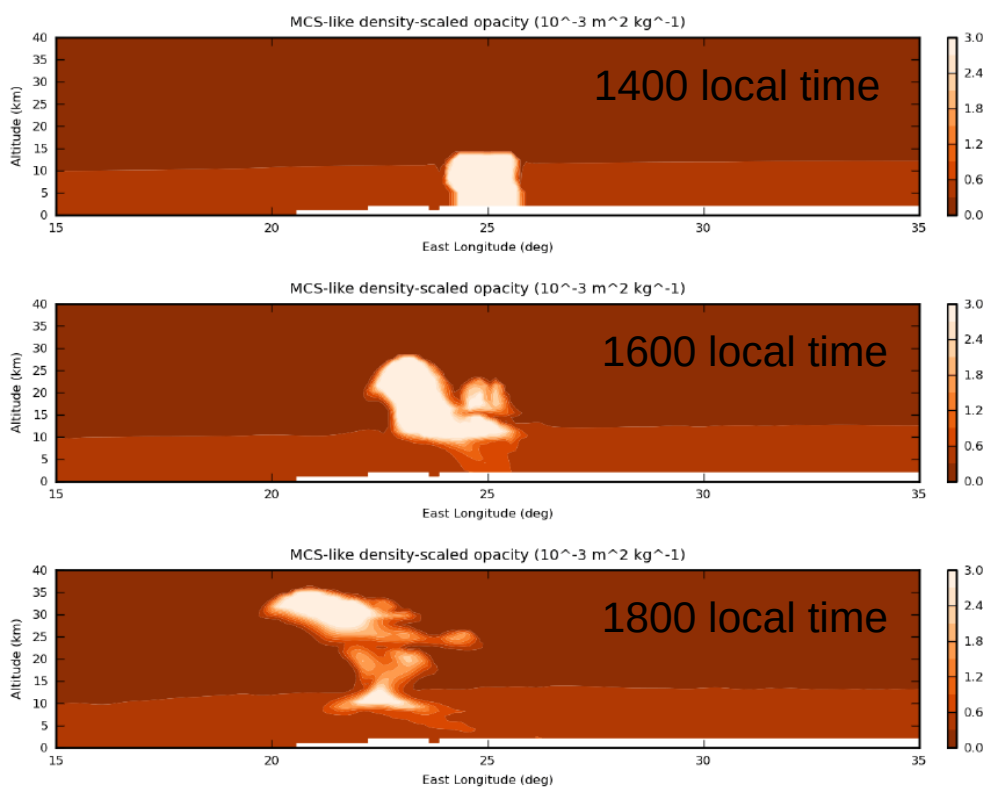
[Kleinboehl et al., GRL 2013]





Due to the sun-synchronous orbit of MCS's carrier spacecraft MRO, coverage is limited to local times close to MRO's equator crossing times.

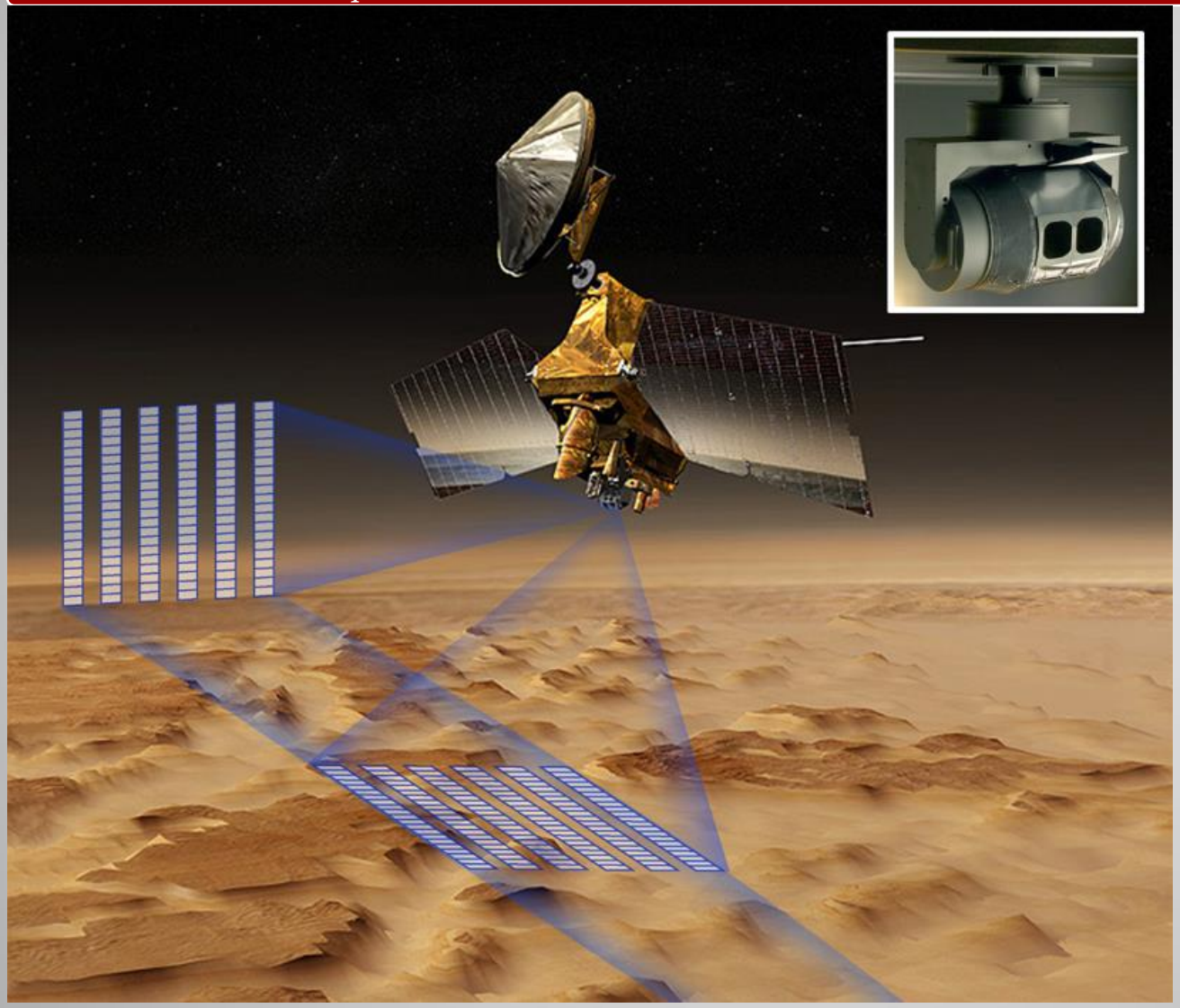
Do we have convective activity on Mars?



- Dust suspended in the atmosphere is heated by the sun
- The heating can cause atmospheric instability, which makes the dusty air rise and draw more dust into the atmosphere: **"pseudo-moist convective activity"**
- Figures show mesoscale simulation of dust convective activity

[Spiga et al., JGR 2013]

Mars Climate Sounder heritage



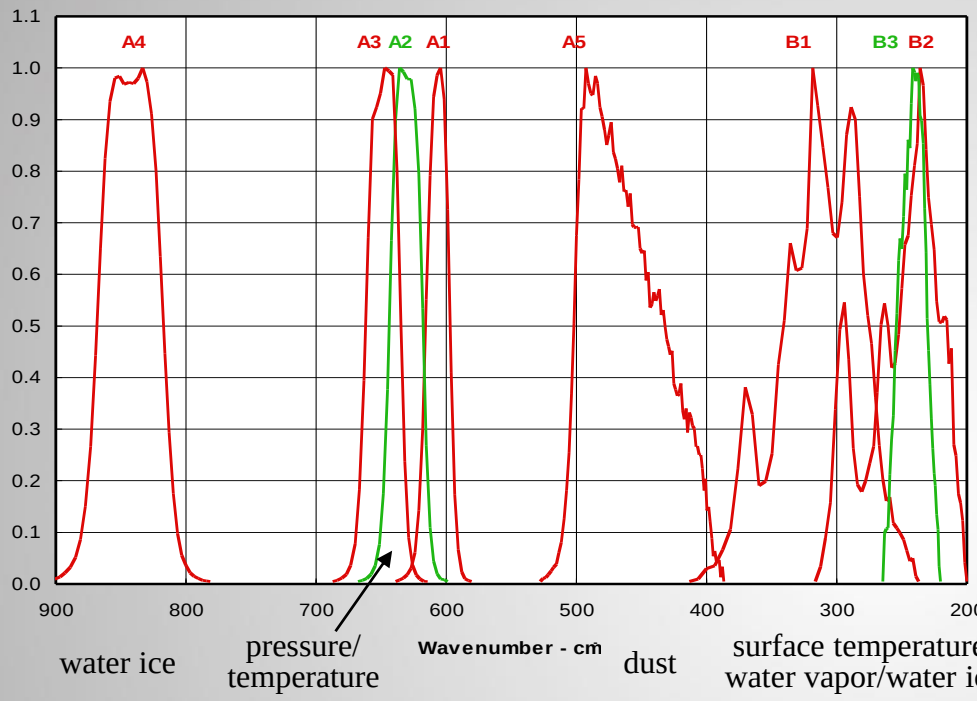
Approach is based on technology used for Mars Climate Sounder (MCS).

MCS consists of nine channels distributed over two telescopes, which can be pointed through actuators.

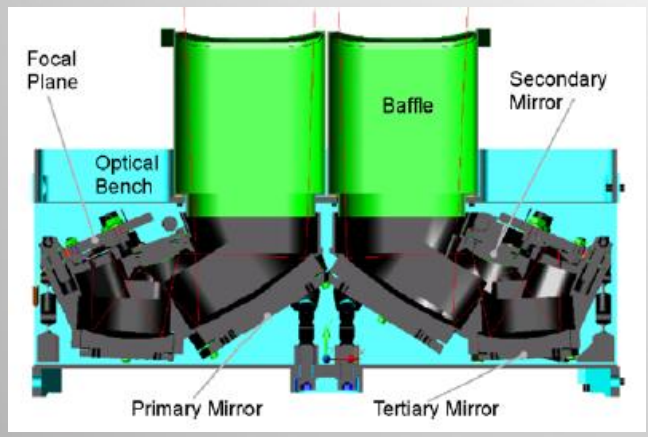
Each MCS channel has 21 detectors, covering an altitude range from the surface to ~80 km when pointed at the limb.

Measurements in limb geometry yield vertical profiles of temperature, dust and water ice opacity at a resolution of ~5 km.

Spectral coverage



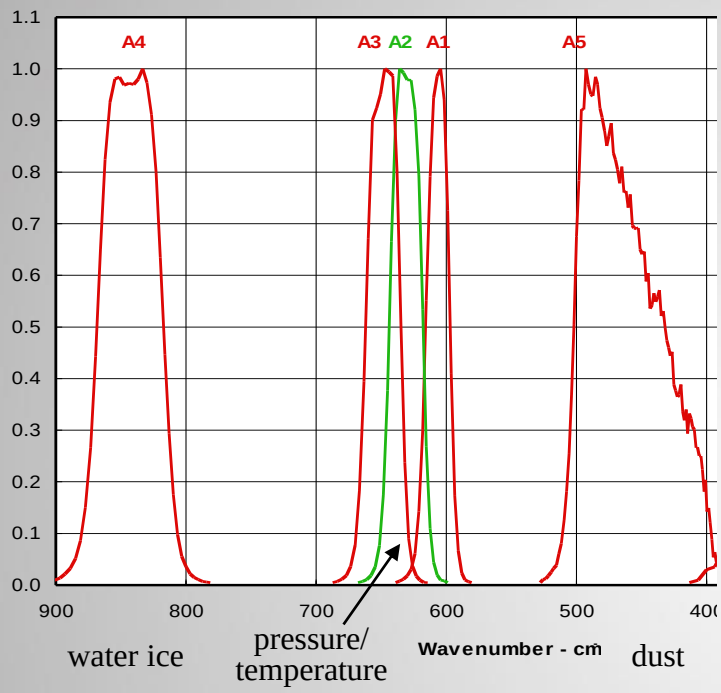
MCS has eight infrared channels covering frequencies form 200 – 900 cm^{-1}, and a broad-band visible channel.



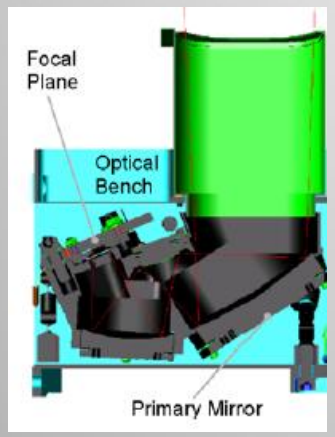
Mid-IR channels use interference filters and are located in one telescope, while far-IR channels use mesh-filters and are located in a second telescope.

[McCleese et al., JGR 2007]

Accommodation in cubesat



- A **single telescope fits into 1U**
- One telescope could accommodate the MCS mid-IR channels necessary for temperature, dust and water ice profiling
- Additionally either a visible channel or an IR channel for surface temperature could be accommodated
- Telescope would not be actuated – instead a rotating mirror could provide alternated views of the limb for profiling, nadir for surface and lower atmospheric measurements, and space for offset calibration
- Gain calibration on ground likely sufficient – no need to carry black body target

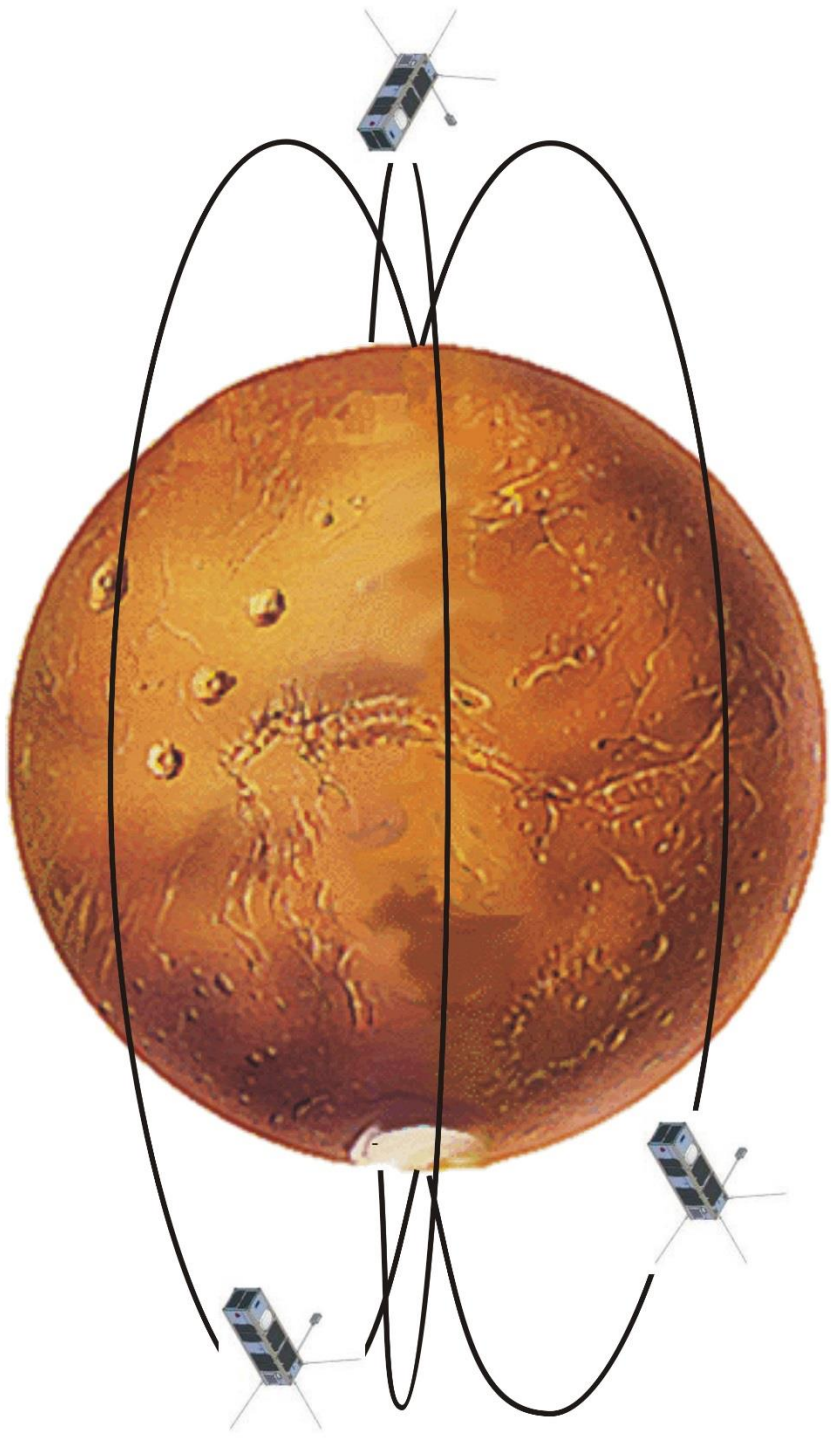


Cubesat constellation*

- 3-4 cubesats in sun-synchronous orbits provide global coverage at 6-8 local times

- Local time coverage around 10 AM, 1 PM, 4 PM sufficient to resolve daytime pseudo-moist convection as well as semi-diurnal tides in the tropics

- Challenges:
  - Limb pointing requires accurate attitude control (~10-20 mrad)
  - Advanced orbit control required to establish and maintain orbital configuration



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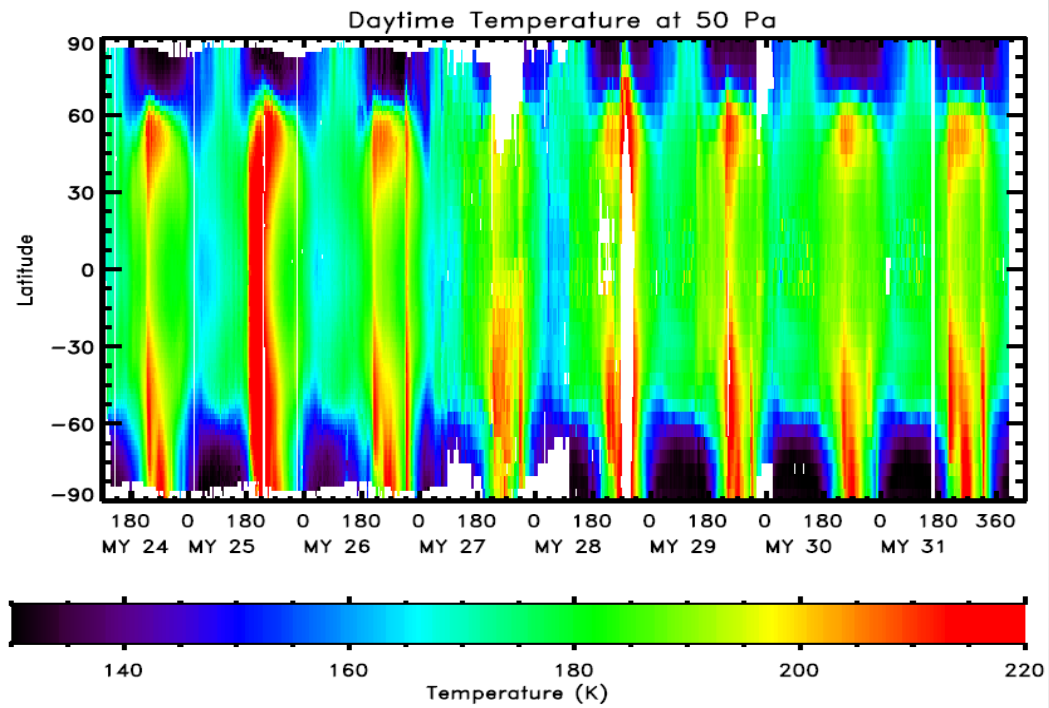
Continuation of a multi-year climatology and EDL support with single instrument



A **single instrument** on a **single cubesat** would allow the continuation of a the multi-Mars-year atmospheric climatology that started in 1997 with TES and is still being extended today with MCS measurements.

A **single instrument** would be able to provide monitoring of atmospheric temperature and dust conditions essential for supporting entry, descent and landing (EDL) of future landers and rovers on Mars.

Left: MCS temperature profiles over the Phoenix landing site prior to EDL (green) and on landing day (black).

Far left: Reconstructed temperature profile from Phoenix landing *[Blanchard and Desai, JSR 2011]*.